HETA 98–0003–2698
Potlatch Corporation – Minnesota Pulp and Paper Division
Cloquet, Minnesota

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PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Ronald M. Hall, Elena Page, Dino Mattorano, and Greg Kinnes of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Analytical support was provided by Data Chem Laboratories, Salk Lake City, Utah. Desktop publishing was performed by Nichole Herbert. Review and preparation for printing was performed by Penny Arthur.

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Health Hazard Evaluation Report 98–0003–2698
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Cloquet, Minnesota
July 1998

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SUMMARY

On October 1, 1997, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) at the Potlatch Corporation – Minnesota Pulp and Paper Division (PCMPPD) plant in Cloquet, Minnesota. The request, from the Duluth Building and Construction Trades Council, concerned potential worker exposures during the construction of a new boiler. The primary concern was for emissions generated from three adjacent operating boilers. The reported health effects were headache and respiratory symptoms. Since April 1997, PCMPPD and company–contracted environmental consultants have sampled for more than 100 different chemical compounds at the construction site in an effort to identify the source of the workers' symptoms. However, PCMPPD and the environmental consultants did not sample for ozone.

An industrial hygiene and medical evaluation was conducted on November 19–21, 1997. Sampling efforts during the evaluation were focused on potential worker exposures incurred from the nearby operating boilers and welding operations. Area air samples at the construction site were collected for ozone, chlorine, volatile organic compounds (VOCs), nitric oxide (NO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and inorganic acids (hydrofluoric, hydrochloric, nitric, phosphoric, sulfuric, and hydrobromic acid). Personal breathing zone (PBZ) samples were collected for elements potentially generated by welding operations. Fifteen employees were interviewed. Medical records were reviewed for two of the interviewed employees and two employees who were no longer working at the construction site.

The peak area ozone concentration measured was 0.37 parts of ozone per million parts of air (ppm). This is nearly four times the NIOSH ceiling limit of 0.1 ppm. The time–weighted average (TWA) ozone concentration was 0.12 ppm. This indicates a potential to exceed the Occupational Safety and Health Administration (OSHA) permissible exposure limit (0.1 ppm) and the American Conference of Governmental Industrial Hygienist (ACGIH®) Threshold Limit Value (TLV®) for light work (0.1ppm), moderate work (0.08 ppm), and heavy work (0.05 ppm). Another area sample had a peak ozone concentration of 0.1 ppm, which is at the NIOSH ceiling limit. The TWA at this area location was 0.04 ppm which is below OSHA and ACGIH® exposure criteria for ozone. Results of air samples collected for chlorine, elements, VOCs, NO, NO_2, SO_2, and inorganic acids were all below the most stringent applicable environmental criteria.

Six of the 15 interviewed employees reported intermittent symptoms temporally related to work, especially when a foul odor was present. These symptoms were eye irritation, cough, and sore throat. Two employees reported transient health effects consisting of hoarseness, eye irritation, lightheadedness, headache, and skin irritation after

a release of some unknown chemicals. There were several reports of gastrointestinal or respiratory illness. These were not temporally related to work, and resolved despite continued work at PCMPPD. Of the employees who were not interviewed, but whose records were reviewed, one had been removed from work after a steam release inside the plant (not on the stacks) had caused him some respiratory difficulty. Another employee had been diagnosed with asthma that was exacerbated by exposure to irritants at PCMPPD.

Ozone may be generated from electrostatic precipitators (located on the adjacent boiler vent stacks) and welding operations. Concentrations of ozone at the construction site were measured above the NIOSH REL and have the potential to exceed the OSHA Permissible exposure limit (PEL) and ACGIH® TLVs®. Some of the symptoms reported by the workers at the construction site (i.e., irritating odor, irritation of the eyes and throat, cough, headache, chest discomfort, shortness of breath, and tiredness) are consistent with ozone exposure. Vent stack emissions may also contain concentrations of other respiratory irritants (i.e., sulfur dioxide, nitrogen dioxide, and formaldehyde). Recommendations were made to install siding on the north and east sides of the boiler house first and to conduct additional environmental monitoring for ozone.

Keywords: SIC 3443 (Boiler shop products: Industrial boilers, smokestacks, and steel tanks), ozone, electrostatic precipitators, vent stack emissions, respiratory irritants, and construction.

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INTRODUCTION

On October 1, 1997, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) at the Potlatch Corporation – Minnesota Pulp and Paper Division (PCMPPD) plant in Cloquet, Minnesota. The request, from the Duluth Building and Construction Trades Council, concerned worker exposures during the construction of a new boiler, primarily, to emissions generated from three adjacent operating boilers. The reported health effects were headache and respiratory effects, such as asthma. The construction on the new boiler began in 1996 and the number of construction workers at the site varied between 400 and 450.

In response to the request, NIOSH investigators conducted an environmental and medical evaluation at the construction site of the new boiler on November 19–21, 1997. Given the specific concerns of the workers and the possibility for stack emissions (from adjacent operating boilers) to migrate through the construction area, the sampling efforts during the NIOSH evaluation were focused on worker exposures incurred from the nearby operating boilers.

BACKGROUND

At the time of the NIOSH site visit, PCMPPD was constructing a new recovery boiler (Boiler # 10) as part of the plant's modernization program. Workers belonging to various trade unions have been employed by contractors working at PCMPPD in the construction of the new boiler. Some of the trades represented at the construction site include carpenters, electricians, cement masons, boiler makers, ironworkers, welders, insulators, plumbers, steam fitters, laborers, and other related construction trades. The construction of the new boiler house (Boiler # 10) was scheduled for completion in April of 1998.

The new recovery boiler (Boiler # 10) is located close to three other operating boilers (Boiler #7, #8, and #9). Boiler #7 is a power boiler which burns primarily bark (from logs used in the pulp manufacturing process) and primary wastewater sludge. Boiler #9 is also a power boiler which burns primarily bark and sludge and Boiler #8 is the current recovery boiler which burns mainly black liquor from the pulp manufacturing process. Boiler #7 and Boiler #9 are also used to combust non–condensible gases from the pulping process. Boiler #10 is being constructed to replace Boiler #8. The vent stacks from Boilers #7 and #8 are approximately 253 feet in elevation, and the elevation of the vent stack from Boiler #9 is approximately 278 feet.

During April 1997, when the construction on the new boiler was approximately 198 feet in elevation, workers reported various symptoms such as headaches, eye and throat irritation, nasal congestion, chest discomfort, cough, dizziness, difficulty breathing, and a metallic taste in the mouth. These symptoms were reported when emissions from the adjacent operating boilers migrated through the construction area. This migration occurred when the wind was blowing from a north to northeast direction. During the time of the NIOSH site visit (November 19–21,1997), construction on the new boiler was occurring at an elevation of approximately 270 feet (from ground level), and air samples were collected on November 20, 1997, when the wind was blowing from a northeast direction.

Since April 1997, PCMPPD and company–contracted environmental consultants have sampled for more than 100 different chemical compounds at the construction site in an effort to identify the etiologic agent responsible for the workers' symptoms. Some of the sampled compounds included contaminates that may be present from the paper manufacturing process (e.g., SO_2, NO_2, NO, dimethyl sulfide, hydrogen sulfide, and mercaptans). Sampling for various other chemical compounds was performed in an effort to identify unknown contaminants at the construction site. The majority of the collected samples showed non–detectable concentrations. Some chemical compounds, which have the potential to cause irritation of the respiratory system were detected at low concentrations (i.e., SO_2 and NO_2). Air samples for formaldehyde revealed concentrations up to 0.137 parts of formaldehyde per million parts of air (ppm).

PCMPPD has contracted an environmental consultant to perform daily environmental monitoring at the construction site with real–time instruments for carbon monoxide (CO), chlorine dioxide, hydrogen sulfide, methane, lower explosive limits, SO_2, and formaldehyde. The environmental consultant has been given the authority to shut down construction operations if any high levels (levels that exceed the Minnesota Occupational Safety and Health Administration [OSHA] permissible exposure limits [PEL]) of these compounds are detected.

PCMPPD and the environmental consultants did not sample for ozone at the construction site. Ozone is generated from oxygen in the vicinity of electrical sources.[1] Ozone can be produced industrially from oxygen by means of ultraviolet generators or by passing air through a high–voltage, alternating–current electrical discharge.[1] Electrostatic precipitators have the capability to produce ozone. A NIOSH study at a cement company found ozone concentrations approaching 5 ppm when an operating electrostatic precipitator back–drafted into a kiln.[2] Ozone may also be generated during inert–gas–shielded arc welding where, depending on the gas flow, ozone concentrations may be as high as 6 – 9 ppm.[1] These studies suggest that it is plausible for ozone production to occur as a result of the large electrostatic precipitators located on each of the operating boiler stacks adjacent to the construction area and/or during welding operations at the construction site.

METHODS

Industrial Hygiene

A walk–through inspection of the new boiler construction site was conducted on November 19, 1997, to familiarize NIOSH personnel with the construction activities and work areas where smoke emissions have the potential to migrate. On November 20, 1997, full–shift area samples for VOCs, NO, NO_2, SO_2, and inorganic acids were collected at five area locations (see Figure 1 for area sample locations): (1) ground level at the base of the new boiler house on the west side of the construction area (location A1); (2) at the 207–foot elevation level near the newly constructed electrostatic precipitator (location A2); (3) at the 270–foot elevation level in the north east corner of the new boiler construction area (location A3); (4) at the 207–foot elevation level on the north side of the new boiler house (location A4); and (5) outside the evaporator building on a stair case near the new boiler house (location A5).

Ozone samples were collected in two separate areas at the new boiler construction site. The first monitoring site was located on the north side of the new boiler house at area location A2 (see Figure 1). The electrostatic precipitator located on the new boiler (Boiler #10) was still under construction and was not yet operational. The second monitoring site was on a stair well at area sample location A3 (see Figure 1). These two area locations were selected based on the drifting of smoke (from the operational boiler stacks adjacent to the construction site) through the construction area. Chlorine samples were also collected at location A3. In addition to area samples, PBZ samples for elements were collected on five workers who performed welding operations at the construction site.

Ozone

Ozone samples were collected using a Metrosonics pm–7700 toxic gas monitor equipped with a gs–7709 ozone sensor (Metrosonics Inc., Rochester, New York). The pm–7700 toxic gas monitor is a direct reading instrument with data–logging capabilities. This monitor collects four samples per second and reports the measured ozone minimum, average, and maximum concentration every minute. The monitor also reports peak concentrations and the time–weighted average (TWA) concentration over the entire sample period. The ozone concentrations recorded by the monitor were then downloaded to a personal computer for evaluation.

Formaldehyde

Formaldehyde samples were collected using the draft NIOSH method 2016.[3] However, the results of these samples cannot be reported due to analytical complications.

Chlorine

Chlorine samples were collected using a Toxilog Personal Atmospheric Monitor (Biosystems Inc., Rockfall, Connecticut). The Toxilog monitor recorded chlorine measurements every minute during the monitoring period. After the monitoring period, the recorded measurements were downloaded to a personal computer for evaluation.

Elements

PBZ samples for elements were collected on workers who performed welding during construction on the new boiler house. These samples were quantitatively analyzed for silver, aluminum, arsenic, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, lithium, magnesium, manganese, molybdenum, sodium, nickel, phosphorus, lead, platinum, selenium, tellurium, thallium, titanium, vanadium, yttrium, zinc, and zirconium using a Thermo Jarrell Ash ICAP–61 inductively coupled argon plasma, emission spectrometer according to NIOSH Method 7300.[3] These samples were collected on 37–millimeter (mm) diameter (0.8–micrometer [µm] pore–size) mixed cellulose ester membrane filters (MCE), using sampling pumps calibrated at 2 liters per minute (Lpm).

Volatile Organic Compounds (VOCs)

Area air samples were collected on thermal desorption tubes to qualitatively identify VOCs. The thermal desorption tubes were attached by Tygon® tubing to sampling pumps calibrated at a flow rate of 50 cubic centimeters per minute (cc/min). Each thermal desorption tube contained three beds of sorbent material: a front layer of Carbopack Y™, a middle layer of Carbopack B™, and a back section of Carboxen 1003™. The thermal desorption tubes for low level VOCs were analyzed by the NIOSH laboratory using stainless steel tubes configured for thermal desorption in a Perkin–Elmer ATD 400 automatic thermal desorption system and analyzed using a gas chromatograph with a mass selective detector.

Nitric Oxide (NO) And Nitrogen Dioxide (NO_2)

Area air samples for NO and NO_2 were collected on sorbent tubes (oxidizer+triethanolamine–treated molecular sieve) in accordance with NIOSH sample method 6014.[3] The sorbent tubes were attached by Tygon® tubing to sampling pumps calibrated at a flow rate of 25 cc/min. These samples were analyzed by manual visible spectrophotometry.

Sulfur Dioxide (SO_2)

Area air samples for SO_2 were collected on Na_2CO_3 treated cellulose filters preceded by 0.8 µm cellulose ester membrane filters. The filters were attached by Tygon® tubing to sampling pumps calibrated at a flow rate of 500 cc/min. The samples were analyzed for sulfate ion concentration by ion chromatography according to NIOSH method 6004.[3] Reported results from the ion chromatography were then converted to SO_2.

Inorganic Acids

Area samples for inorganic acids (hydrofluoric, hydrochloric, nitric, phosphoric, sulfuric, and hydrobromic acid) were collected on solid sorbent tubes (washed silica gel, 400 milligrams (mg)/200 mg with glass fiber plug) attached by tubing to sampling pumps calibrated at a flow rate of 200 cc/min. The samples were analyzed for fluoride, chloride, nitrate, phosphate, bromide, and sulfate ion concentrations by ion chromatography according to

NIOSH sampling method 7903.[3] The ion results were then converted to the respective acid.

Medical Evaluation

The NIOSH physician interviewed 15 employees who presented themselves for interviews. Her availability was made known to them by both management and their unions. All were asked to provide medical records if they had seen a physician. Two of the interviewed employees released medical records for review, and PCMPPD provided medical records for two employees who were no longer working at PCMPPD.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre–existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH recommended exposure limits (RELs)[4], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®)[5] and (3) the U.S. Department of Labor, OSHA permissible exposure limits (PELs)[6]. In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA–approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

A TWA exposure refers to the average airborne concentration of a substance during a normal 8–to–10–hour workday. Some substances have recommended short–term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short–term.

Ozone

Low concentrations of ozone (0.01 ppm to 0.05 ppm) may produce a sharp, irritating odor even during brief exposures.[7] Symptoms of ozone exposure include irritation of the eyes, dryness of the nose and throat, and cough. If ozone concentrations continue to rise, more severe symptoms may develop. These symptoms may include headache, pain or tightness in the chest, and shortness of breath or tiredness.[7] Short–term exposure (a few hours) to ozone concentrations on the order of 0.1 ppm has been shown to produce temporary decreases in measured lung volumes in humans.[8]

The NIOSH REL for ozone is 0.1 ppm and is to be measured as a ceiling limit.[4] A ceiling limit is a peak concentration that should not be exceeded at any time during the workday. NIOSH has also recommended an immediately dangerous to life and health (IDLH) limit of 5 ppm for ozone.[9] The current OSHA PEL for ozone is 0.1 ppm for an 8–hour (40–hour work week) TWA.[6] The current ACGIH® TLV® is based on the amount of physical exertion or work load required for the job being accomplished and is to be average over an 8–hour period. The TLV® is 0.1 ppm for jobs requiring light physical exertion, for moderate physical exertion the TLV® is lowered to 0.08 ppm, and for heavy physical exertion the TLV® is lowered to 0.05 ppm.[5]

RESULTS

Industrial Hygiene

Ozone

Figure 2 presents the average and maximum ozone concentrations collected each minute during the sampling period at location A2. The peak ozone concentration measured at this location was 0.37 ppm. This is nearly four times the NIOSH ceiling limit of 0.1 ppm. The TWA ozone concentration at this area location was 0.12 ppm. These values indicate that there is a potential to exceed the OSHA PEL (0.1 ppm) and the ACGIH® TLV® for light work (0.1ppm), moderate work (0.08 ppm), and heavy work (0.05 ppm) at this area location.

The peak ozone concentration measured at location A3 was 0.1 ppm, which is at the NIOSH ceiling limit. The TWA ozone concentration at this area location was 0.04 ppm and is below OSHA and ACGIH® exposure criteria. See Table I for a summary of ozone sampling results.

Chlorine

Chlorine samples were collected at location A3 with a Toxilog monitor and other various locations throughout the construction site with detector tubes. No chlorine was detected during the evaluation.

Elements

All five PBZ samples collected for elements (metals) during welding operations had concentrations less than applicable exposure criteria for each element analyzed (silver, aluminum, arsenic, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, lithium, magnesium, manganese, molybdenum, sodium, nickel, phosphorus, lead, platinum, selenium, tellurium, thallium, titanium, vanadium, yttrium, zinc, and zirconium). The highest detectable concentrations for four of the elements were between 16 and 74 percent of the most stringent occupational exposure criteria (zinc oxide 74%, lead 38%, titanium dioxide 16%, and calcium oxide 23%). The most stringent occupational exposure criteria in this report is defined as the lowest occupational exposure criteria level set by NIOSH RELs, OSHA PELs, or ACGIH® TLVs®. All other elements included in the analysis were less than 15% of the most stringent environmental criteria. It should be noted that titanium dioxide is an agent recommended by NIOSH to be treated as a potential occupational carcinogen.[4]

Volatile Organic Compounds (VOCs)

Area samples were collected on thermal desorption media to qualitatively identify VOCs at five locations throughout the boiler construction area (see Figure 1). All of the area samples collected for VOCs contained very low concentrations of acetonitrile, toluene, pinene, xylene, propane, methoxypropoxy propanol, methyl hexanone, siloxanes, styrene, methyl pyrrolidinone, and various aliphatic hydrocarbons. These concentrations are generally in the parts per billion range (ppb) and well below any applicable exposure criteria.

Nitric Oxide (NO) and Nitrogen Dioxide (NO_2)

Area air samples for NO and NO_2 were collected in the same locations as the VOCs. The analytical limit of detection (LOD) for NO is 0.5 microgram (μg)/sample, which equates to a minimum detectable concentration (MDC) of 42 mircrograms per cubic meter (μg/m^3) or 0.031 parts of NO per million parts of air (ppm), based on an air sampling volume of 12 liters. The analytical limit of quantification (LOQ) for NO is 2 μg/sample, which equates to a minimum quantifiable concentration (MQC) of 167 μg/m^3 (0.12 ppm), assuming a sample volume of 12 liters. The analytical LOD for NO_2 is 0.8 μg/sample, which equates to a MDC of 67 μg/m^3 (0.037 ppm), based on an air sampling volume of 12 liters. The analytical LOQ for NO_2 is 3 μg/sample, which equates to a MQC of 250 μg/m^3 (0.14 ppm), assuming a sample volume of 12 liters.

The area samples collected at A4 and A2 (see Figure 1) had detectable NO concentrations between the MDC and the MQC. NO concentrations on all other area samples were at or below the MDC. The area sample collected at A4 had a NO_2 concentration between the MDC and the MQC. NO_2 concentrations on all other area samples were at or below the MDC.

Sulfur Dioxide (SO_2)

Area samples for SO_2 were collected from the same five sample locations that the VOC, NO, and NO_2 samples were collected. The analytical LOD for SO_2 is 0.7 μg/sample, which equates to a MDC of 2.9 μg/m^3 (0.001 ppm), based on an air sampling volume of 245 liters. The analytical LOQ for SO_2 is 2 μg/sample, which equates to a MQC of 8.2 μg/m^3 (0.003 ppm), assuming a sample volume of 245 liters.

The area sample collected at A4 (see Figure 1) had a SO_2 concentration of 23 μg/m^3 (0.008 ppm). All the other area samples collected for SO_2 were at or below the MDC. All the area samples collected for SO_2 had concentrations that were less than 1% of the most stringent environmental criteria.

Inorganic Acids

Area samples for inorganic acids were collected from the same five sample locations for VOC, NO, and NO_2. All area samples collected for inorganic acids had concentrations less than 1% of the most stringent environmental criteria for each acid analyzed (hydrofluoric, hydrochloric, nitric, phosphoric, sulfuric, and hydrobromic acid).

Medical

The 15 employees who presented for interview represented 3 contractors, and several trades – boiler maker, sheet–metal, ironworker, electrician, and foreman. Their duration of employment at this job site ranged from approximately 1 month–1 year, with the majority being 2–6 months. Six of the 15 interviewed employees (out of approximately 400 to 450 employees) reported intermittent symptoms temporally related to work, especially when a foul odor was present. These symptoms were eye irritation, cough, and sore throat. In September 1997, two other employees reported transient health effects consisting of hoarseness, eye irritation, lightheadedness, headache, and skin irritation after a release of unknown chemicals in a separate area of the plant, which was not related with the construction of the # 10 boiler. The employees were treated at an emergency room and released. Neither had current health problems. Several employees reported self–limited gastrointestinal or respiratory illness. These were not temporally related to work, and resolved despite continued work at PCMPPD. Of the two employees who were not interviewed and were no longer working on site, but whose records were reviewed, one had been kept off work by his physician after a steam release inside the plant (not from the vent stacks) had caused him some respiratory difficulty. Two other employees were involved, but had not missed work. The other employee had been diagnosed with asthma that was exacerbated by exposure to irritants at PCMPPD, and was currently working at another job.

DISCUSSION

Studies suggest that it is plausible for ozone production to have occurred as a result of the large electrostatic precipitators located on each of the operating boiler stacks adjacent to the construction area and/or during welding operations at the construction site.[1,2] Smoke from the boiler vent stacks can migrate across the construction site when the wind is blowing from a north or northeast direction. During our evaluation, the wind was blowing from the northeast and some of the smoke from the adjacent stacks did migrate into the construction area. Ozone concentrations detected at the construction site indicate that workers have the potential to be overexposed to ozone.

Formaldehyde concentrations up to 0.137 ppm have been detected by environmental consultants (contracted by PCMPPD) at the construction site. Irritation symptoms (i.e., irritation of the eyes, throat, and nose) may occur in people exposed to formaldehyde at concentrations below 0.1 ppm, but more typically these symptoms begin at exposures of 1.0 ppm and greater. Cases of formaldehyde–induced asthma and bronchial hyper–reactivity developed specifically to formaldehyde are uncommon.[10] NIOSH has identified formaldehyde for its potential carcinogenic properties as a suspect human carcinogen and has set an REL of 0.016 ppm (8–hr TWA) and a ceiling limit of 0.1 ppm (15 min).[4] This REL was based on analytical chemistry capabilities at the time (1976); environmental investigators should be aware that this level may not be protective. The OSHA PEL is 0.75 ppm as an 8–hour TWA and 2 ppm as a STEL.[6] ACGIH has designated formaldehyde to be a suspected human carcinogen and therefore, recommends that worker exposure by all routes should be carefully controlled to levels "as low as reasonably achievable" below the TLV. ACGIH has set a ceiling limit of 0.3 ppm.[5]

Samples collected for elements, NO, NO_2, SO_2, and inorganic acids all had concentrations less than the most stringent applicable exposure criteria.

CONCLUSIONS

Ozone samples collected at area sample location A2 indicate that there is a potential for workers to be exposed to ozone concentrations above established occupational exposure criteria. Many of the symptoms reported by the workers at the construction site (i.e., irritating odor, irritation of the eyes and throat, cough, headache, chest discomfort, hard to breathe, and tiredness) are consistent with ozone exposure. One individual experienced an exacerbation of his asthma which may have been due to ozone exposure. Health effects related to ozone exposure are self–limited, and should not result in long–term health effects in these workers. Vent stack emissions may also contain low concentrations of other respiratory irritants (i.e., sulfur dioxide and nitrogen dioxide) which may have the potential to cause some of these symptoms. Formaldehyde may also have the potential to cause some of the reported symptoms at the construction site.

RECOMMENDATIONS

The following recommendations were addressed at the survey close–out meeting (November 21, 1997) and/or in an interim report sent to PCMPPD and the Duluth Building and Trades Council on December16, 1997. The recommendations were reportedly implemented by PCMPPD.[11] After implementation, reports of health effects from the construction workers to PCMPPD and the Duluth Building and Trades Council have dramatically decreased.[12, 13]

1. The risk of exposure to ozone and other respiratory irritants may be increased by emissions from the adjacent boiler stacks migrating into the construction area. To help reduce the migration of smoke emissions into the new boiler construction area, it is recommended that the siding on the north

and east side of the new boiler house be completed first.

2. To target all sources of ozone emissions (boiler vent stacks and/or welding operations), it is recommended that additional ozone monitoring be conducted by the company. The company should identify any areas where ozone concentrations may exceed the established evaluation criteria (i.e., NIOSH REL, ACGIH® TLV®s, or OSHA PEL). Ozone samples should be collected during welding operations and environmental worst–case scenarios such as thermal inversions and wind blowing from the north that forces smoke emissions (from adjacent boiler vent stacks) toward the construction site. These samples should be collected in any areas where work activities are conducted. If samples indicate that exposure criteria may be exceeded, steps need to be taken by the company to reduce worker exposures.

3. Engineering controls should be used to reduce worker exposures wherever feasible. Administrative controls and personal protective equipment (PPE) (i.e., respirators) are designed to protect workers from airborne exposures when engineering controls are not feasible or not effective in reducing air contaminates to acceptable levels. Administrative controls are currently in place at the new boiler construction site. These controls include worker removal from elevated construction levels to ground level if a worker experiences any symptom of exposure. We recommend that these administrative controls be continued. Other administrative controls may include limiting the amount of time that workers are permitted to work in the construction area. This may reduce the TWA exposures. However, this practice may not be successful in reducing worker exposures below exposure criteria ceiling limits.

4. PCMPPD has contracted an environmental consultant to perform daily environmental monitoring with direct reading instruments for CO, hydrogen sulfide, methane, lower explosive limits, SO_2, and formaldehyde at the construction site. The environmental consultant has the authority to stop construction operations if any high levels of these compounds are detected. It is recommended that this practice continue until all construction activity on the new boiler is completed.

A system should be implemented for reporting health effects related to work on this project. All persons with reported health effects should be evaluated by an occupational medicine physician, preferably the same one or group, so that trends or patterns can be observed and evaluated.

If engineering and administrative controls are not sufficient to reduce worker exposures below established exposure criteria for ozone, then respirators may be used to protect the workers at the construction site. For respirators to be worn by employees, an appropriate respiratory protection program must be utilized by the company and be in accordance with OSHA regulation 29 CFR 1910.134.[14] There are commercially available chemical cartridge respirators for ozone. However, NIOSH has not certified any cartridge–based respirator for ozone. Supplied air respirators are approved by NIOSH for protection against ozone exposures less than 1 ppm.[7] Supplied air respirators deliver clean air through a supply hose to the worker's respirator face piece. It is essential that the air delivered to the respirator be free from contaminants and monitored frequently in accordance with OSHA regulation 1910.134.[14]

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Figure 1. Area Sample Locations (Elevations are from Ground Level)

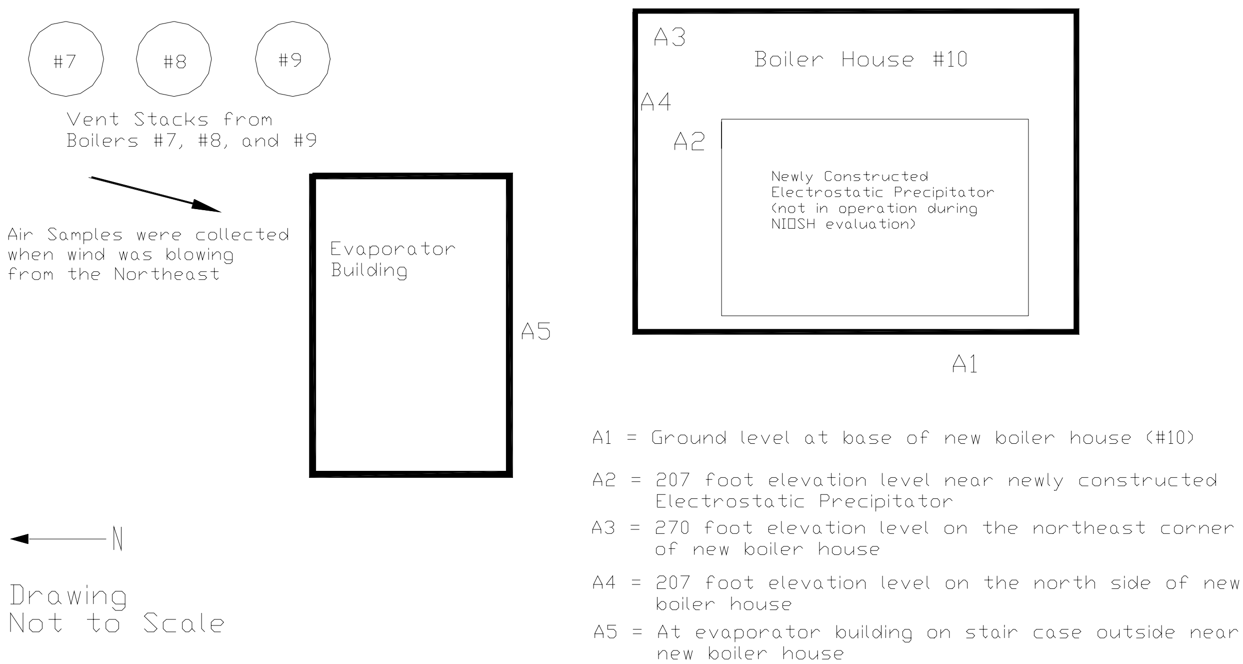

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Figure 2. Ozone average and maximum concentrations plotted each minute during the sampling period at area sample location A2 (207 foot elevation).

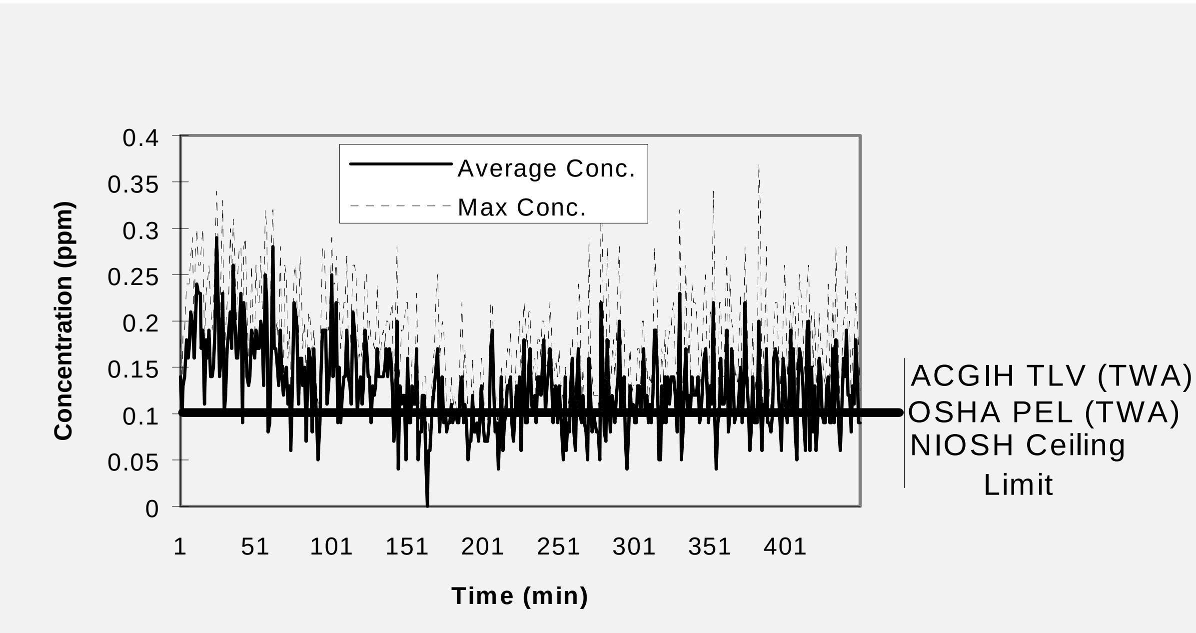

Table 1. Summary of ozone sampling results

Location	Peck concentration (ppm)	TWA concentration (ppm)
Location A2 (207 foot elevation)	0.37	0.12
Location A3 (270 foot elevation)	0.1	0.04
Ozone Evaluation Criteria NIOSH ceiling limit 0.1 ppm. OSHA PEL 0.1 ppm ACGIH® TLV® for light work (0.1ppm), moderate work (0.08 ppm), and heavy work (0.05 ppm)		

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